IITRI

FIRE DEPARTMENT OPERATIONS ANALYSIS
Final Report

Contract DAHC 20-70-C-0208
OCD WORK UNIT 2522F

June 1970

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For the analysis and correlation, the data have been grouped into two classes - residential and nonresidential. Except for those from Los Angeles, most of the fire reports were of residential fires. The data are compared to corresponding data from the Chicago area fires.

SIGNIFICANT FINDINGS

1. Operations of fire departments within the four cities considered show similar trends to those determined for the Chicago Metropolitan Area.

2. The diverse types of fires and the small sample size (ten fires from each city) do not permit definitive conclusions regarding the observed differences in fire department operations in various cities.

3. Correlations developed using data from the Chicago Metropolitan Area provide interim information for other cities.

4. Brigade activities should be limited to knockdown of fires, leaving the final extinguishment to self-help teams.*

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*See footnote on page 1 of Summary.

OBJECTIVE AND SCOPE

In a previous study,* fire department operations within the Chicago Metropolitan Area were examined. Necessary data were obtained from reports prepared by fire chiefs acting as consultants to the project.

The objective of this study is to obtain data from a wider geographical area in order to refine and modify correlations previously developed. The scope of work consists of expanding the previous study to include the analysis and correlations of fire department operations in approximately 40 additional fires from four different regions in the United States which differ from the Chicago area.

APPROACH

The operational analysis was made from data received in reports from fire chiefs of four different cities. The cities are Los Angeles, Calif., Buena Park, Calif., New York, N. Y. and White Plains, N. Y.

In each report prepared, an attempt was made to provide a time history (as complete as possible) from the estimated ignition time to the final extinguishment and overhaul, including the time of arrival of each piece of fire department apparatus and the actual time required to bring the fire under control. All reports were prepared in a uniform manner on forms supplied to the fire chiefs by IITRI. Each report included plan view sketches indicating the location of the fire origin (where possible), the extent of the fire area, the location and description of hose lines and fire suppression apparatuses, and a narrative description of the fire.

*Labes, W. G., "Fire Department Operations Analysis," IIT Research Institute Report for Office of Civil Defense, Contract DAHC20-70-C-0208, OCD Work Unit 2522F, January 1968.

IIT RESEARCH INSTITUTE
10 West 35th Street
Chicago, Illinois

SUMMARY OF
RESEARCH REPORT

FIRE DEPARTMENT OPERATIONS ANALYSIS

by

Frederick Salzberg

June 1970

For
Office of Civil Defense
Office of the Secretary of the Army
Washington, D.C. 20310

Contract DAHC20-70-C-0208
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OCD REVIEW NOTICE

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense

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FOREWORD

This report summarizes the final phase of studies concerning the operation of fire departments. The work was sponsored by the Office of Civil Defense, Washington, D.C.; Contract DAHC20-70-C-0208; Task Order 2520(68); OCD Work Unit 2522F (IITRI Project J6163).

The data required to perform the analyses were provided by the following consultants whose assistance is gratefully acknowledged.

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W. McGill, Fire Chief
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W. B. Conwell, Fire Chief
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C. L. McCown, Battalion Chief
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Respectfully submitted,
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ABSTRACT

Fire department operations were studied in New York, N. Y., White Plains, N. Y., Los Angeles, California and Buena Park, California. The study was performed using data on ten fires in each city. Correlations were developed involving water application, time and manpower required for suppressing various sizes of structural fires. Results were compared with fire department operations within the Chicago Metropolitan Area that were determined in other studies.

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1. INTRODUCTION

1.1 Need for Studying Fire Department Operations

In recent years numerous studies have convincingly demonstrated the ability of a nuclear detonation to produce a large number of fires in an exposed urban area. These fires could have catastrophic consequences both in terms of human casualties and destruction of property. Therefore it is essential for urban areas to have fire defenses against thermal effects of nuclear detonations.

Because of the severity of the fire situation, these defenses must include several levels of fire suppression activities ranging from the efforts of untrained individuals (self-help) to professional fire departments. Suppression activities at each level will play an important part in the overall defense picture. Thus self-help teams by reducing the number of ignitions, reduce the initial and thus the overall magnitude of the fire problem. Brigades, by suppressing fires which have flashover, prevent structural involvement and decrease the fire intensity and the potential of fire spread. Similar results are obtained from the efforts of professional fire departments in suppressing fully involved building fires.

Each of the levels differ in regard to personnel training, equipment, and water quantities required. However, for all practical purposes brigades can be assumed to have capabilities similar to professional fire departments. The personnel, although not as highly trained as the professional fire fighters, must be able to suppress fires which have flashover. Similarly in regard to the manpower, equipment, and water, multiple teams of brigades can be employed to provide an equivalence between brigade and professional fire department capabilities.

Because of this equivalence, the defenses of urban areas against fires produced by nuclear detonation, can be broadly

considered to be provided by self-help and brigade teams. In connection with the latter, information needed for planning purposes includes water application rates and quantities, manpower, and control time of fires. These data can be obtained from the analysis of professional fire departments, and such an analysis was the objective of the studies described in this report.

1.2 Scope of Work

In the past IIT Research Institute (IITRI) studied the operations of fire departments located within the Chicago Metropolitan Area. Necessary data were obtained from reports prepared by fire chiefs acting as consultants to the projects. The objective of this study was to obtain data from a wider geographical area in order to refine and modify correlations previously developed. Specifically, the scope of work required that "studies previously conducted under Contracts N228(62479) 69031 and N00228-67-C-0701 on 134 fires will be expanded to include the analysis and correlations of fire department operations in approximately 40 additional fires over four United States regions which differ from the Chicago area. Efforts will include any refinements and modifications of previous correlation methods which can be identified."

2. DATA

In this section the data procured for performing the analysis of the fire department operations are discussed. First, considerations are given to the pertinent stages occurring during development of the fire and suppression operation. This is done in order to clarify the terminology used and also to bring into focus the significance of the quantities considered in evaluating the suppression operations.

2.1 Significant Parameters

The development of a fire within a structure and the effects of fire fighting operations, can be characterized in terms of several significant parameters described schematically in Fig. 1 (Ref. 1). As indicated in this figure, the first significant event following the start of fire is the flashover. The flashover represents a significant increase in the fire intensity, and for all practical purposes corresponds to the starting time (T_o) of accelerated fire spread through the structure. Experimental evidence (Ref. 2) indicates that in the absence of fire fighting operations, the structural involvement by fire would proceed at an exponential rate, as depicted by Curve I in Fig. 1. The activity of the fire fighting decreases this rate of development (Curve II), and the fire area after reaching some maximum value (A_2) begins to decrease (Curve III).

The duration of fire prior to the start of fire fighting operation is the preburn time (T_p). During this time the fire increases in area and can also involve concealed spaces, increasing the difficulty of extinguishment.

Fire fighting time required to stop the increase of fire is called control time (T_c). During this time the suppression operations reach their maximum, both in manpower and water application. At control time the fire area also reaches its maximum values (A_2). The duration of the fire fighting after the control

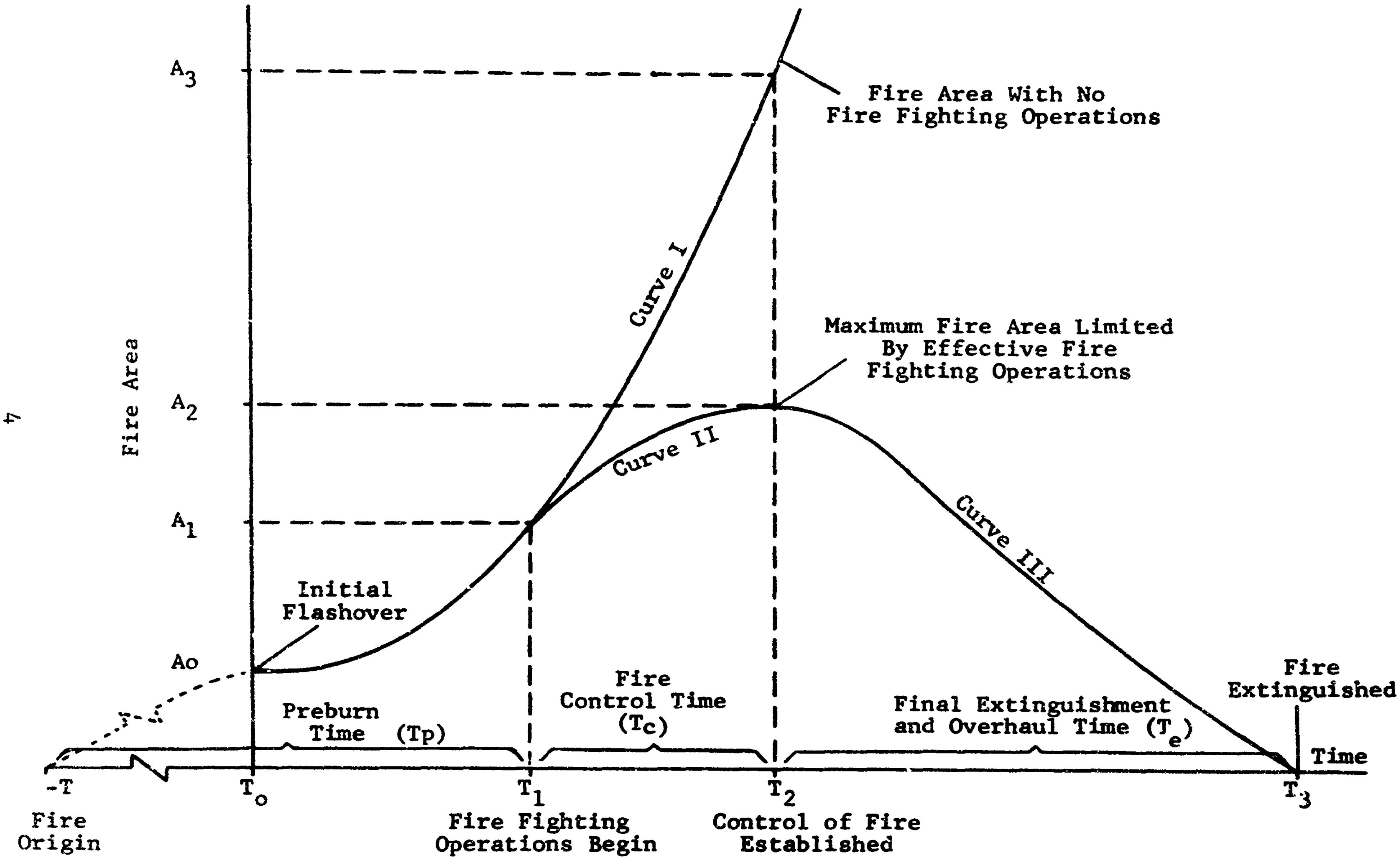

FIG. 1 FIRE TIME-HISTORY CURVES

has been established is referred to as the final extinguishment and overhaul time (T_e). At the end of this period the fire has been completely extinguished.

The maximum fire area (A_2) is a significant quantity since in essence it indicates the effectiveness of fire suppression operation in controlling the fire. The smaller A_2, all other conditions remaining the same, indicates more efficiency in fire fighting. It must be noted, however, that this criterion may not be applicable to the final extinguishment and overhaul. These operations, as mentioned above, depend also on fire involvement of concealed spaces. Unfortunately, this information is usually not available. Some conjecture, could be made using the preburn time. The preburn time is often unreliable due to the lack of the fire origin time. Thus any information deduced on the basis of the preburn time must be considered as approximate only.

2.2 Procurement of Data

2.2.1 Type

Numerous parameters affect both the development and suppression of structural fires. These parameters include location of fire, structural characteristics, type of occupancy and atmospheric conditions. Thus, the location of fire influences its rate of spread through the structure and also accessibility for fire fighting. A fire at the ground level presents less operational problems for fire fighting than a fire at higher floor levels. The combustibility and the internal layout of the structure also affect the rate of fire spread and the suppression operation. In a fire resistive structure the confinement of fire to the floor of origin and lack of fire penetration into concealed spaces lessen both the intensity of the fire as well as the required suppression operations.

In respect to the wood frame and masonry walls, and wood floor buildings, the differences in construction will be of significance primarily in latter stages of fire development. The flashover time and the rate of fire spread throughout these structures will be affected mainly by their geometry, internal layout and content.

The amount, nature and distribution of the contents determines to a considerable degree the intensity of the fire and in turn the necessary fire fighting operations. Unfortunately, all this information is usually not available and must be deduced from the type of occupancy which may be quite inaccurate in a case of nonresidential occupancy.

Generally, moderate atmospheric conditions are not expected to substantially affect the fire fighting. High wind velocities may fan the fire and deflect the water streams from the fire thus reducing the effectiveness of suppression operations. Similarly, prevailing high temperatures and low humidities could increase the fire intensity. An opposite effect is expected from precipitation during the fire. Quantitatively, the effects of these environmental conditions on fire behavior and suppression operations are not known at this time.

Information collected is shown in Table I. As indicated in this table, in addition to the detailed description of fire suppression operations, numerous supplementary data were obtained. The latter are essential for a complete analysis of the fire suppression efforts.

2.2.2 Method

Data necessary for the analysis were obtained from the reports on fire suppression operations prepared by fire chiefs active in the cities considered. All reports were prepared in a uniform manner using a standardized procedure similar to the one developed in Ref. 1. Each fire report included plan view sketches indicating the location and extent of the fire

TABLE I

INFORMATION COLLECTED

Structural Characteristics

- Construction type
- Wall material
- Floor covering
- Roof construction and covering
- Interior wall and ceiling finish
- Floor openings
- Exterior wall openings
- Age of structure

Type of Occupancy

- Residential
- Commercial
- Industrial
- Institutional
- etc.

Environmental Conditions

- Temperature
- Wind velocity
- Precipitation
- Humidity

History of Fire

- Time when fire started
- Cause of ignition
- Material initially ignited
- Time of fire discovery
- Time and type of alarm transmission
- Development of fire within the structure
- Extent of physical damage
- Production of firebrands
- Casualties

Fire Suppression Operations

- Extent of fire fighting by occupants
- Name and number of companies responding
- Type of each apparatus
- Capacity of pump and water tank
- Manning of apparatus (paid, volunteer and number of men)
- Sources of water supply
- Incoming residual pressure
- Length, type, size of hose line and nozzles
- Discharge pressure on lines
- Ladder pipes
- Use of standpipe and automatic sprinklers
- Placement and length of lines
- Time and use of each hose line
- Amount of water used
- Time of control
- Time of extinguishment and overhaul
- Rescue efforts

area, the location of hose lines and fire suppression apparatuses, and a narrative description of the fire.

Locations selected for studying the fire department operation include:

- New York, New York
- White Plains, New York
- Los Angeles, California
- Buena Park, California

These locations were selected because they represent widely separated geographical areas within the United States and also permit comparison of large and small size fire departments.

The distribution of fire reports by occupancies, including those considered in Ref. 1 for the Chicago Metropolitan Area, is shown in Table II. Except for the City of Los Angeles, most of the fire reports obtained (outside of the Chicago Metropolitan Area) pertain to residential occupancies.

All data obtained are summarized in Appendix A as tables. Included are brief remarks highlighting each fire.

TABLE II

DISTRIBUTION OF FIRES STUDIED

Occupancy	Chicago* Metropolitan	New York	Los Angeles	Buena Park	White Plains
Residential	63	8	2	7	7
Mercantile & Residential	14				
Industrial	16		3	1	1
Mercantile	15		5	1	1
Business & Mercantile	2				
Business & Mercantile	3				
Assembly	1	1		1	
Hotel	5				
Farm Building	2				
Storage	5	1			1
Assembly & Residential	2				
Lumber Yard	2				
Business	3				
Mercantile & Manufacturing	1				

*Analyzed in Ref. 1.

3. ANALYSIS

3.1 Relationships Considered

An analysis of fire suppression operations involves numerous parameters, some only approximately known due to the difficulty in securing reliable data. For this reason, a large number of fire fighting studies is required in order to develop accurate relationships describing the effects of all pertinent parameters. This was infeasible with available data and the analysis was limited to only two broad categories of occupancies -- residential and nonresidential. The maximum fire area (at the control time) was used as the independent variable in developing various relationships. These relationships were similar to those of Ref. 1. This was done in order to obtain a direct comparison between the fire department operations within the Chicago Metropolitan Area studied previously, and four other selected locations.

Specifically, the relationships considered involved the following quantities, all expressed as functions of maximum fire area:

- Average water application rate density (gpm/ft^2)
- Average water application rate (gpm)
- Average quantity of water used for control (gals)
- Average control time (min)
- Average manpower present
- Average man-hours expended.

Water application rates refer to the maximum values used in achieving control of the fires. The averages of these quantities for fire areas within specified class ranges, were used in correlating the data. A distinction is made between the manpower present and the manpower expended, because some personnel present at the fireground may not actively participate in the fire suppression activities.

3.2 Discussion of Results

Water quantities and the control times used in suppressing fires within the Chicago Metropolitan Area; New York and White Plains, N.Y.; Los Angeles and Buena Park, Calif. are shown as a table in Appendix B. The corresponding manpower is also given as a table in this appendix. The plots of these quantities are presented in Figs. 2 through 5.

Values for the Chicago area are averages of many fires, whereas those corresponding to other cities are in most cases for single fires. As an example, for fire areas smaller than 500 ft^2 only one report was available from Los Angeles compared to 28 reports from Chicago.

A review of the graphs shows that average values from the Chicago area correlate reasonably well with the fire area. There is some scatter of data which would, however, become much more pronounced in plots using actual rather than average values. Various factors may be responsible for this scatter. These may involve uncertainties in fire development and differences in operational procedures.

Because of small sample sizes and the scatter of data, it is difficult to draw definitive conclusions regarding the differences between fire fighting in Chicago areas and other cities studied. Nevertheless, examination of the graphs indicates that in regard to water applications and control times, the data from other cities exhibit trends similar to those determined for the Chicago area. It is of interest to note that the application rate densities (gpm/ft^2) on residential fires (Fig. 2), were mostly well above those used in suppression of experimental building fires. The difference was less pronounced in connection with water application rates (gpm), and some values even corresponded to those obtained during the experimental fires.

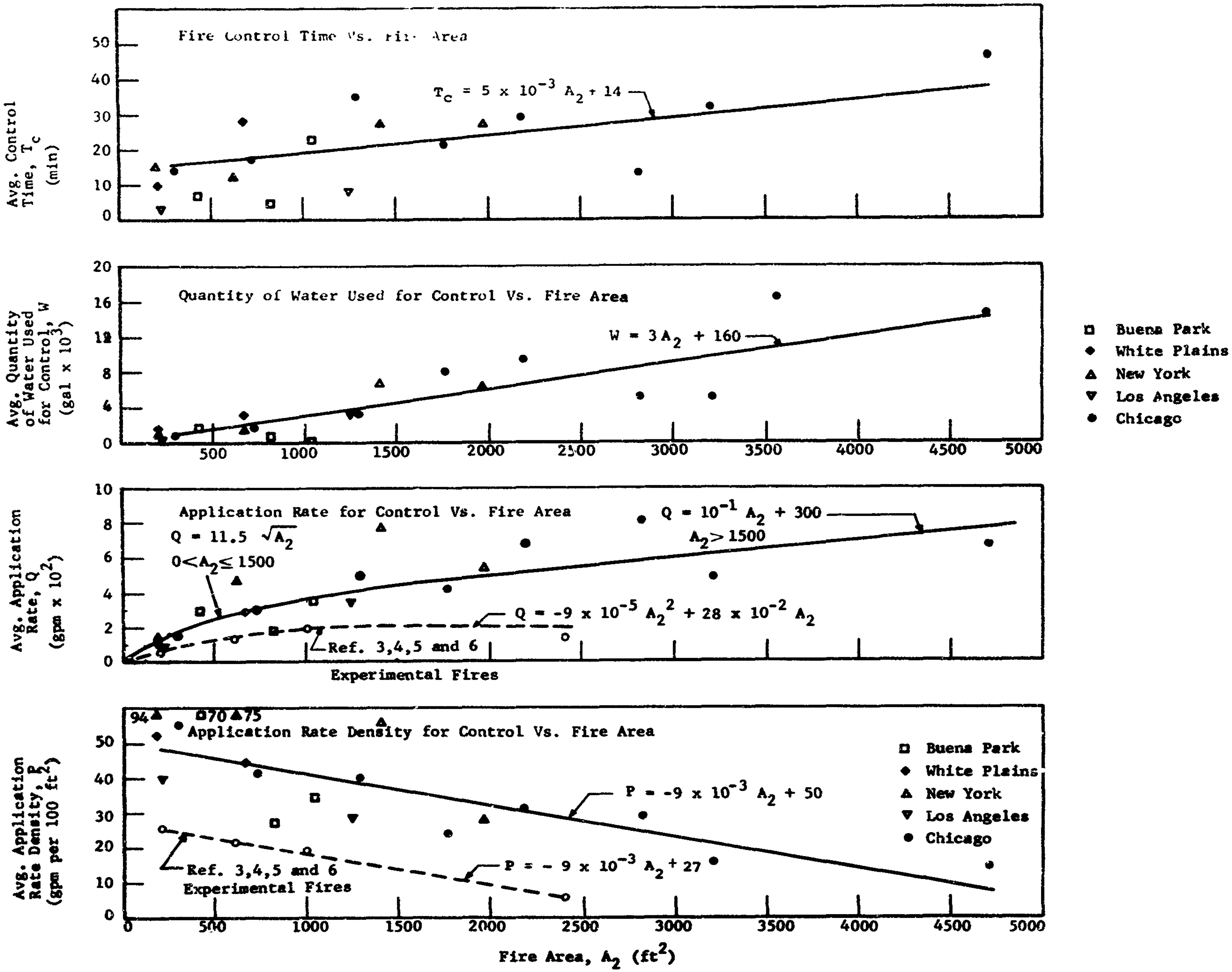

Fig. 2 WATER APPLICATION AND TIME USED TO CONTROL RESIDENTIAL FIRES
(Average Within Each Class)

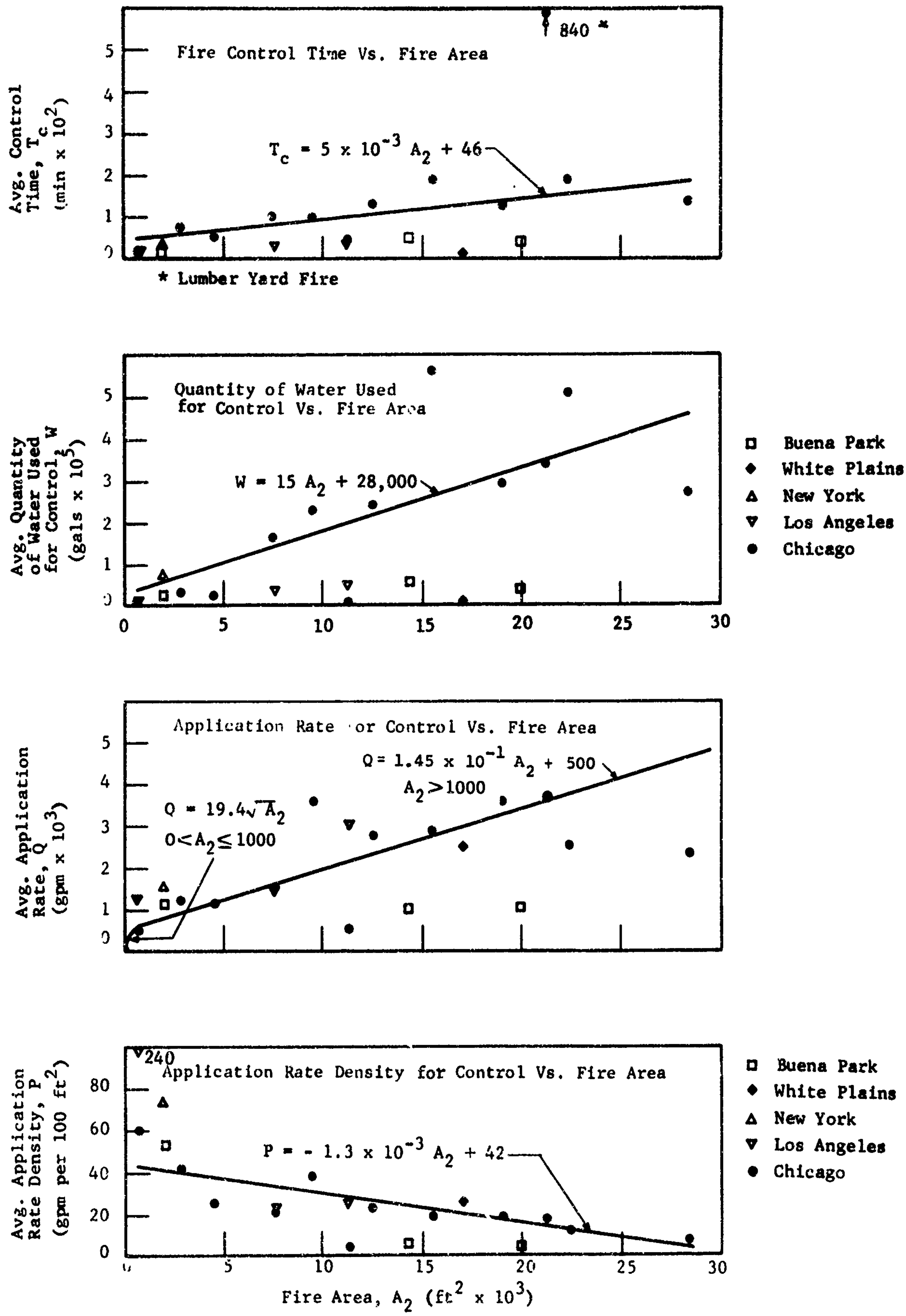

Fig. 3 WATER APPLICATION AND TIME USED TO CONTROL NONRESIDENTIAL FIRES (Average Within Each Class)

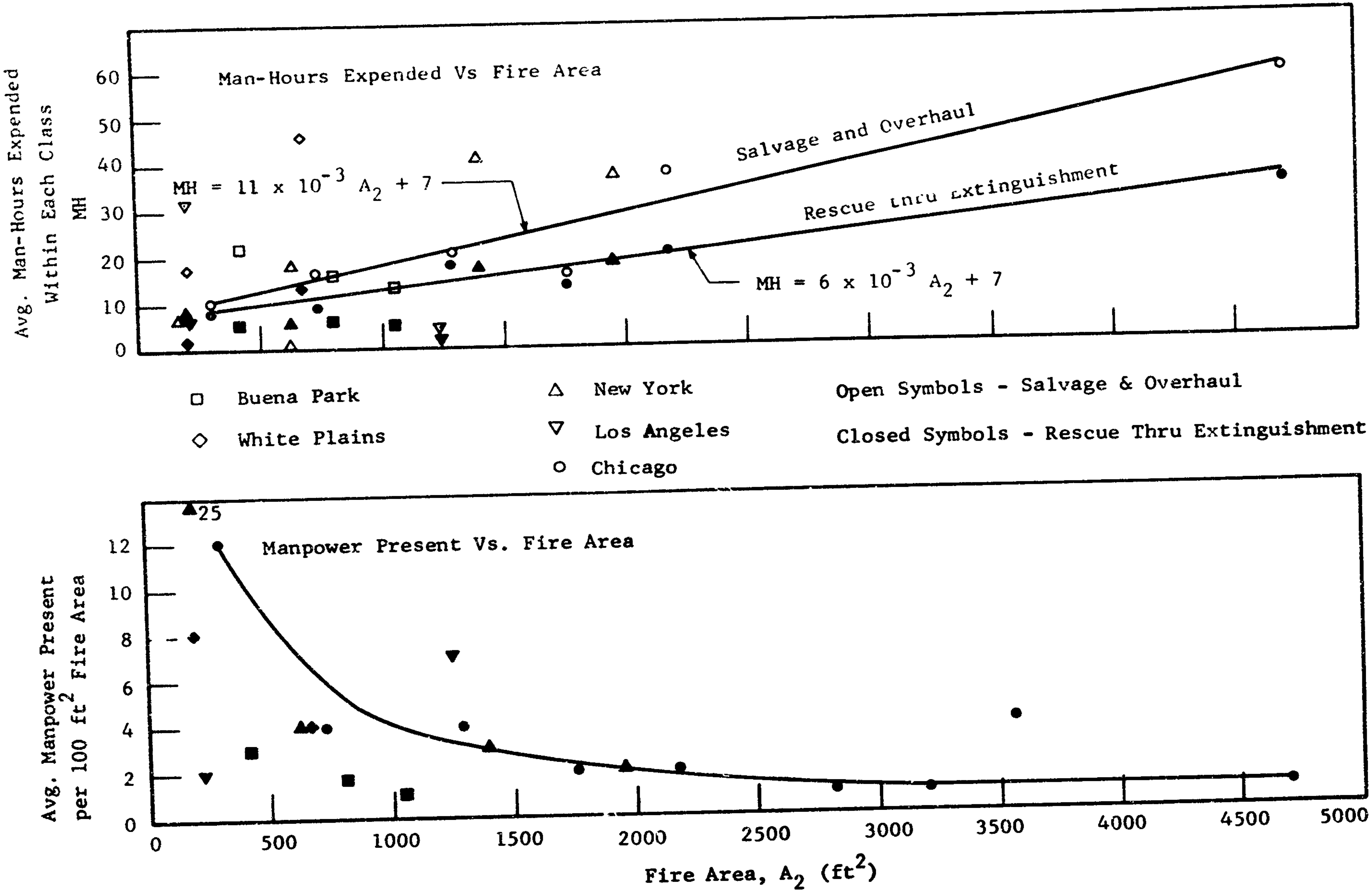

Fig. 4 MANPOWER PRESENT AND MAN-HOURS EXPENDED IN SUPPRESSING RESIDENTIAL FIRES
(Average Within Each Class)

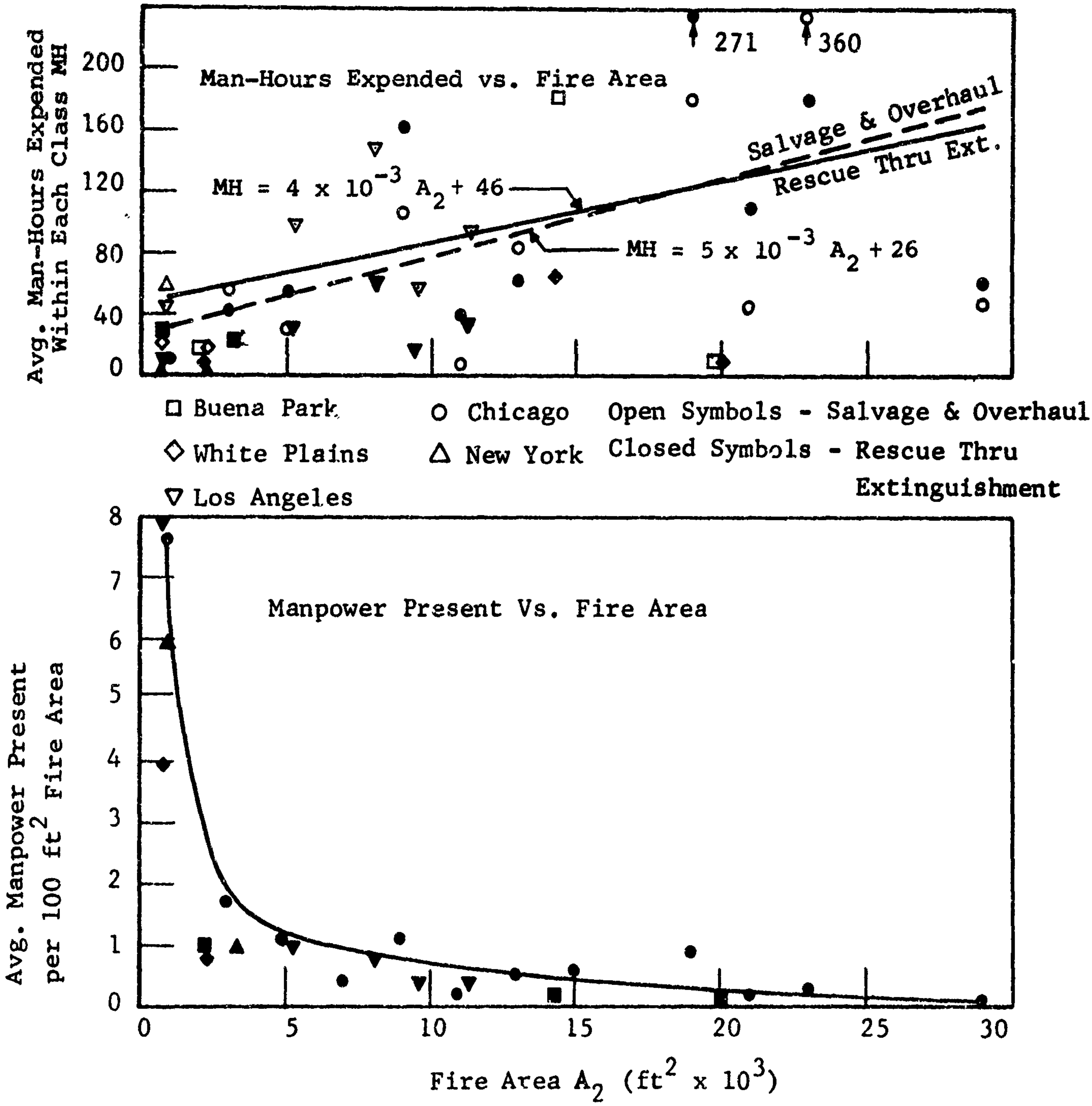

Fig. 5 MANPOWER PRESENT AND MAN-HOURS EXPENDED IN SUPPRESSING NONRESIDENTIAL FIRES (Average Within Each Class)

The suppression of nonresidential fires shows larger discrepancies between the Chicago area and other cities than observed with residential fires. This is particularly true in connection with water quantities used to control fires having areas larger than 5000 ft^2. The manpower present and man-hours expended in suppressing fires are shown in Figs. 4 and 5 for residential and nonresidential fires, respectively. Surprisingly larger variations between the cities were obtained in connection with the residential fires, than were obtained with nonresidential fires. In either case the variation of data may reflect the differences between man-manpower response policies of various fire departments. These differences are quite apparent from Tables III and IV, showing typical examples of fire department responses in a large and small city, respectively (Ref. 1).

3.3 Application

As indicated in the introduction, the fire defense of urban areas against thermal effects from nuclear detonation can be structured in terms of self-help and brigade teams. The activities of self-help teams are limited to suppression of ignition and possibly to overhaul and salvage, leaving suppression of fires past flashover to brigades. As readily seen in Figs. 4 and 5, relegating the salvage and overhaul to self-help teams would substantially decrease the time required for brigades to spend with each fire and thus increase their ability to handle a much larger number of fires. The use of self-help teams for salvage and overhaul may require some additional equipment and training to be provided for the teams. This would be more than offset by the benefit derived in increasing the effectiveness of brigades.

The information developed during this study is primarily of interest to the operation of brigades. Several types of brigade units were postulated in Ref. 1 and those are summarized in Table V. Using this information and the relationships of Figs. 2 and 3, the number of brigade units, quantity of water, and time required to control structural fires can be evaluated.

TABLE III

FIRE ALARM RESPONSE IN A LARGE CITY

Type of Apparatus	Man-power Per Unit	TELEPHONE (STILL ALARM)				BOX ALARM All Districts											
		High Value Districts		Other Districts (Incl. Residential)		Initial Alarm		2nd Alarm		3rd Alarm		4th Alarm		5th Alarm		Special Alarms	
		No. of App.	No. of Men	No. of App.	No. of Men	No. of App.	No. of Men	No. of App.	No. of Men	No. of App.	No. of Men	No. of App.	No. of Men	No. of App.	No. of Men	No. of App.	No. of Men
Engine Company (E)	5	3	15	2	10	4	20	4	20	4	20	4	20	4	20	As Requested By Officer-in-Charge	Varies According To Apparatus Requested
Ladder Company (L)	5	2	10	1	5	2	10	2	10	1	5						
Squad Company (S)	5	1	5	1 OR	5 OR	1	5	1	5	1	5						
Snorkel Squad Company (Sn Sq)	9	1	9	1	9	1	9	2	18								
Snorkel Company Sn	3					1	3										
Battalion Chief	2	1	2	1	2	2	4	2	4								
Division Marshall	2					1	2										
Deputy Fire Marshall	2							1	2								
Chief Fire Marshall	2									1	2						
Apparatus and Man-power Response		8	41	5	22 or 26	12	53	12	59	7	32	4	20	4	20		
Cumulative Apparatus & Manpower Response						12	53	24	112	31	144	35	164	39	184		

TABLE IV

FIRE ALARM RESPONSE IN A SMALL CITY AND ITS RURAL AREA

FIRE DISTRICT INFORMATION

Land Area In Fire District - 36 square miles

Population - Within City - 8,000 people
- Within Entire Fire District - 12,000 people

Fire Department Manpower - Four paid men
- Twenty-one volunteers on call

Alarms received by telephone

STRUCTURAL FIRE IN A HIGH VALUE DISTRICT

Order of Response	Apparatus	Manpower
Initial Alarm	3 Engines 1 Ladder Truck 1 Emergency Truck	Entire department of 25 men respond
First call for help from nearby towns	1 Engine	5 men respond

STRUCTURAL FIRE IN A RURAL AREA OF THE DISTRICT

Initial Alarm	2 Engines 1 Emergency Truck	One-half of department 12 men respond

TABLE V

TYPES OF BRIGADE TEAMS

Brigade Team Type Designation	Number of Men Per Team	Size of Hose Lines (in.)	Number of Hose Lines	Potential Water Application Rates Per Team
A	4 or 5	1	2	2, 30 gpm streams totaling 60 gpm
B	4 or 5	1-1/2	1	80 gpm
C	4 or 5	2-1/2	1	150 gpm
D	8 or 10	2-1/2	2	2, 250 gpm streams totaling 500 gpm

Tables VI and VII show these quantities as functions of brigade types for knockdown of residential and nonresidential fires, respectively. The knockdown of fires refers to suppression of fires beyond the control point until no flaming appears. No overhaul and salvage operations would be performed by brigade units, and the control time represents approximately the duration of fire fighting operations.

TABLE VI

BRIGADE TEAMS REQUIRED FOR RESIDENTIAL BUILDING FIRES

Fire Area A_2 (ft^2)	App. Rate Q (gpm)	Control Time T_c (min)	Quantity of Water W (gals)	NUMBER OF BRIGADE TEAMS FOR KNOCKDOWN			
				Type A 60 gpm/Team	Type B 80 gpm/Team	Type C 150 gpm/Team	Type D 500 gpm/Team
100 or less	115 or less	15 or less	460 or less	2	1	1	1
200	163	15	760	3	1	1	1
300	199	16	1060	3	2	1	1
400	230	16	1360	4	3	2	1
500	257	17	1660	4	3	2	1
750	315	18	2410	5	4	2	1
1000	364	19	3160	6	5	2	1
1250	407	20	3910	7	5	2	1
1500	445	22	4660	7	5	3	1
1750	478	23	5410	8	6	3	1
2000	503	24	6160	8	6	3	1
2250	528	25	6910	8	6	3	1
2500	553	27	7660	9	7	3	1

TABLE VII

BRIGADE TEAMS REQUIRED FOR NONRESIDENTIAL BUILDING FIRES

Fire Area A_2 (ft^2)	App. Rate Q (gpm)	Control Time T_c (min)	Quantity of Water W (gals)	NUMBER OF BRIGADE TEAMS FOR KNOCKDOWN			
				Type A 60 gpm/Team	Type B 80 gpm/team	Type C 150 gpm/team	Type D 500 gpm/team
500 or less	435 or less	49 or less	35500 or less	7 or less	5 or less	3 or less	1
1000	613	51	43000	10	8	4	2
2000	800	56	58000	14	10	6	2
3000	950	61	73000	--	12	7	2
4000	1100	66	88000	--	14	8	3
5000	1250	71	103000	--	--	9	3
6000	1400	76	118000	--	--	10	3
7000	1550	81	133000	--	--	11	4
8000	1700	86	148000	--	--	12	4
9000	1850	91	163000	--	--	13	4
10000	2000	96	178000	--	--	14	4

4. SUMMARY

The operations of fire departments were studied by IITRI in the past (Ref. 1) using data from 134 fires in the Chicago Metropolitan Area. The objective of this study was to enhance the results obtained by analyzing and comparing fire suppression in other locations within the United States. Specifically, the locations considered include: New York and White Plains, N.Y.; Los Angeles and Buena Park, California. These cities were selected to provide data on operations of fire departments (one small and one large) located in widely different geographical regions.

The study involved 10 fires from each city, i.e., in total 40 fires. Required data were obtained from reports prepared by fire chiefs active in the cities considered. Correlations developed include water application, control time, and manpower required to suppress fires. All quantities were expressed as functions of maximum fire area. Water application requirements for several types of brigade teams for suppressing different size fires were established.

5. CONCLUSIONS

Based on the performed analysis of 40 fires the following conclusions are given:

- Operations of fire departments within four cities considered show similar trends to those determined for the Chicago Metropolitan Area.
- Diverse types of fires and small sample sizes (10 from each city) do not permit definitive conclusions regarding observed differences in fire department operations in various cities.
- Correlations developed using data from the Chicago Metropolitan Area provide interim information for other cities (Table VIII).
- Brigade activities should be limited to knock-down of fires leaving final extinguishment to self-help teams.

TABLE VIII

CORRELATIONS OF FIRE SUPPRESSION OPERATIONS

Quantity	Correlations*	
	Residential	Nonresidential
Water rate density, P (gpm/ft^2)	$P = 9 \times 10^{-3} A_2 + 50$	$P = -1.3 \times 10^{-3} A_2 + 42$
Water rate, Q (gpm)	$Q = 8.9\sqrt{A_2} (A < 1500)$ $10^{-1} A_2 + 303 \ (A_2 \geq 1500)$	$Q = 15.4\sqrt{A_2} (A_2 \leq 1000)$ $1.45 \times 10^{-1} A_2 + 500 \ (A_2 > 1000)$
Water quantity, W (gals)	$W = 3A_2 + 160$	$W = 15A_2 + 28,000$
Control time, T_c (min)	$T_c = 5 \times 10^{-3} A_2 + 14$	$T_c = 5A_2 \times 10^{-3} + 46$
Rescue and extinguishment, MH (man-hours)	$MH = 6 \times 18^{-3} A_2 + 7$	$MH = 4 \times 10^{-3} A_2 + 46$
Salvage and overhaul, MH (man-hours)	$MH = 11 \times 10^{-3} A_2 + 7$	$MH = 5 \times 10^{-3} A_2 + 26$

*Except where shown otherwise, $200 < A_2 < 5,000 \ ft^2$ for residential occupancies, and $1,000 < A_2 < 30,000 \ ft^2$ for nonresidential occupancies.

6. RECOMMENDATIONS FOR FUTURE WORK

The following recommendations are made for future studies related to defenses of urban areas against fires produced by nuclear detonations:

- Obtain additional data on fire fighting in cities considered in order to reach definitive conclusions on fire suppression operations in various regions of the fire in the United States.
- Determine experimentally the optimum approach for controlling structural fires.
- Evaluate the effectiveness of self-help teams in salvage and overhaul operations.
- Study novel methods of controlling fires.

APPENDIX A

DATA OF FIRE DEPARTMENT OPERATIONS IN NEW YORK AND WHITE PLAINS, N.Y.; LOS ANGELES AND BUENA PARK, CALIF.

For symbols and abbreviations used in Tables IX, X, XI, XII, see page 39

TABLE

SUMMARY OF DATA FR

Fire Number	Occupancy Class and Description	Building Construction Class	Number of Stories (Height) (ft)	Total Building Area (ft^2)	Building Area Involved by Fire (Fire Area) A_2 (ft^2)	Extent of Structural Involvement	Number of Stories Involved by Fire	Elevation of Fire Origin (Stories)	Fire Time (min): Preburn T_p	Fire Time (min): Control T_c	Fire Time (min): Final Extinguishment and Overhaul T_e	Water Used for Control: Maximum Application Rate Q (gpm)	Water Used for Control: Total Quantity of Water Used (gals)	Water Used for Control: Application Density (gal/100 ft^2)	Water Used for Control: Maximum Application Rate Density (gpm/100 ft^2)	Ext. & Overhaul: Total Quantity of Water Used (gals)	Ext. & Overhaul: Application Density (gals/100 ft^2)	Hand Hose (in.)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
1	Residential	W	1	852	220	2	1	1	22	3	23	88.5	40	18	40	60	27	[illegible]
2	Residential	W	1A	2500	1250	3	2	1	17	8	45	368	3200	256	29	1200	96	[illegible]
3	Mercantile	W	2A (25')	16200	200	3	1	3	18	22	80	103	800	400	52	200	100	[illegible]
4	A Mercantile B Mercantile C Offices (Vacant)		1 1½ 1½	1350 2700 2700	1395	2	1	1	7	31	186	1365	5250	376	98	1000	72	
5	Mercantile	F-R	1 (16')	16000	1750	4	1	1	40	20	140	3035	6500	371	174	800	46	
6	Mercantile (Retail Furniture Store)	M-J	1 (20')	11400	5280	4	1	1	66	44	470	2033	82200	1557	39	8000	151	[illegible]
7	Mercantile	M-J	2AB (2[illegible]')	15000	11250	3	3	1	97	39	U	3004	55000	489	27	11000	98	[illegible]
8	Industrial	W	1	4000	162	2	1	1	5	9	80	1027	1800	1110	634	600	371	[illegible]
9	Industrial	M-J	1 (14')	9520	9520	3	1	1	30	31	282	319	10000	105	3.4	2600	27	[illegible]
10	Industrial	M-J	1 (14')	11120	8000	4	1	1	64	37	U	2303	58720	734	29	30200	378	[illegible]

TABLE IX

TA FROM LOS ANGELES FIRE

&	Fire Streams		Fire Department				Use of Manpower				Man-hours					Weather Data		
Application Density (gals/100 ft^2)	Hand Hose (in.)	Master	Type	Number of Working Companies	Total Manpower	Manpower per 100 ft^2 Fire Area	Rescue	Forcible Entry	Ventilation	Exposure Protection	Extinguishment	Total Man-hours - Columns 24 through 28	Salvage	Overhaul	Total Man-hours Columns 30 and 31	Temperature °F	Visibility	Wind Speed (mph)
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
27	1-1½ 1-1	None	Paid	2E 1L 1 Batt 1S	16	7	None	None	.4	None	1.0	1.4	.6	4.0	4.6	50	Clear	Calm
96	4-1½	None	Paid	2E 2L 1 Batt 1S	25	2	1.8	.1	1.5	.5	3.0	6.9	2.8	29.6	32.4	54	Fog	20
100	1-1½	None	Paid	2E 1L 1 Batt 1 Div	19	9	None	.1	.2	None	1.3	1.6	8.3	11.2	19.5	56	Clear	25-45
72	3-1½ 2-1 2-2½	None	Paid	3E 2L 1S 1 Batt 1 Div	33	2.4	None	.2	2.5	1.7	5.6	10.0	1.0	57.9	58.9	57	Clear	2
46	6-1½ 2-2½ 1-1	1 AP 1T	Paid	5E 2L 1S 1 Batt 1 Div	45	3	None	3.1	None	1.8	8.6	13.5	1.0	58.0	59.0	56	Clear	4
151	1-1 3-1½ 7-2½	None	Paid	6E 3L 1S 2 Batt 1 Div 1SL 1HU	53	1	None	1.7	3.4	1.3	26.4	32.8	2.9	97.8	100.7	58	Rain	16
98	4-1½ 1-1 1-2½	1 LP 1T	Paid	4E 3L 2S 2 Batt 1 Div	47	.4	None	7.7	6.3	1.1	21.5	36.6	11.7	84.8	96.5	53	Lt.-Fog	1
371	3-2½ 2-1½	None	Paid	3E 2L 1 Batt 1 Div	32	19	None	1.4	2.5	3.4	7.3	14.6	None	26.5	26.5	57	Rainy	5
27	1-1 3-1½ 1-2½	None	Paid	4E 3L 1S 1 Batt	38	.4	.2	2.9	2.9	3.3	9.0	18.3	1.9	57.4	59.3	52	Clear	3
378	8-2½ 4-1½	None	Paid	12E 6L 1S 3 Batt 1 Div 1 AU 1 HU 1 LW 1 SU 2 SL	69	.8	None	3.2	2.1	14.6	40.3	60.2	.8	148.7	149.5	52	Clear	2

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Los Angeles

REMARKS FOR TABLE IX

Fire No.	
1.	Arson is suspected to be the cause of this fire in vacant boarded up dwelling. It was knocked down and controlled very quickly, even though there was about a 20 min delay in discovery.
2.	Discovery delayed 10 min, thick fog condition and false report of persons still in building, all contributed to the extensive damage.
3.	Space heater started this early morning fire which burned approximately 10 min before discovery.
4.	A fire bomb thrown against outside wall started this fire in vents and unpartitioned attic space over building. Three alarms were sounded.
5.	This fire had a good start due to approximately 35 min delay in discovery -- after working hours in commercial area. Poor housekeeping added fuel to the fire.
6.	A 60 min delayed discovery allowed this furniture warehouse fire to gain considerable headway before arrival of fire equipment. Delay caused by sight obscuring heavy rain and early morning hour.
7.	This building was closed up tight when all employees left at midnight. The fire started and smoldered for 97 min before being discovered. Fog, tightness of building and the very early morning hour all contributed to the delay.
8.	Two alarm fire caused by poor housekeeping in 50-year-old building -- ground up vinyl material ignited by space heater.
9.	This three alarm blaze gained headway due to delayed discovery because of late hour and the absence of any employee or watchman.
10.	Extensive damage resulted in delayed discovery, poor warehousing in large, undivided area no sprinklers, broken natural gas line, and no access to south and west side of building.

									Fire Time (min)			Water Used for Control				Ext. & Overhaul		St
Fire Number	Occupancy Class and Discription	Building Construction Class	Number of Stories (Height) (ft)	Total Building Area (ft^2)	Building Area Involved by Fire (Fire Area) (A_2 ft^2)	Extent of Structural Involvement	Number of Stories Involved by Fire	Elevation of Fire Origin (Stories)	Preburn T_p (min.)	Control T_c (min.)	Final Extinguishment and Overhaul T_e (min.)	Maximum Application Rate Q (gpm)	Total Quantity of Water Used (gpm)	Application Density (gals/100 ft^2)	Maximum Application Rate Density (gpm/100 ft^2)	Total Quantity of Water Used (gals)	Application Density (gal/ft^2)	Hand Hose (in.)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Residential	M-J	6B (62')	14000	80	1	1	3	10	12	30	100	800	1000	125	200	250	100'x2½ 200'x1½ 1-2½
2	Residential	W	2½ AB (28')	2500	[illegible]24	3	1	2	8	17	40	200	600	185	[illegible]	650	200	1-2½
3	Residential (Vacant)	M-J	5 (48')	10625	625	3	1	5	15	10	110	350	3000	480	56	1000	160	1-1½ 1-2½
4	Residential	W	2½B (28')	7000	636	1	1	2	15	14	34	600	600	94	34	650	102	1-2½
5	Residential	M-J	5B (54')	9750	1350	2	3	3	7	34	95	310	1100	82	23	400	29	100'-2½ 250'-1½ 1-2½
6	Residential	W	2 (25')	1000	1000	3	2	1	15	20	160	1250	12500	862	86	3750	259	4-2½
	Residential	W	3 (32')	1800	450 / 1450	2	3											
7	Residential (Vacant)	M-J	4B U	3875	1930	3	4	Bsmt	11	36	54	780	4000	207	40	1000	52	1-1½ 3-2½
8	Residential (Vacant)	M-J	3 (38')	3000	2000	3	2	2	3	18	160	290	9250	463	15	4000	200	4-2½
9	Synagogue	M-J	4=5B (55')	20000	800	3	1	4	4	45	154	520	3100	387	65	1400	175	3-2½
10	Warehouse & Garage (Vacant)	M-C	1=3 (35')	3200	3200	4	1	1	15	25	395	2700	150000	4688	84	15000	469	3-2½

A

TABLE X

FROM NEW YORK FIR

ire [illegible]	Fire Department				Use of Manpower						Man-hours			Weather Data		
Master	Type	Number of Working Companies	Total Manpower	Manpower per 100 ft^2 Fire Area	Rescue	Forcible Entry	Ventilation	Exposure Protection	Extinguishment	Total Man-hours Columns 24 through 28	Salvage	Overhaul	Total Man-hours Columns 30 and 31	Temperature °F	Visibility	Wind Speed (mph)
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
None	Paid	2E 1L 1S 1AP	35	43	2.3	1.2	1.8	1.8	1.8	8.9	None	9.3	9.3	33	Clear	11
None	Paid	2E 2L 1 Batt	24	7	None	None	.8	1.3	1.6	3.7	None	5.5	5.5	59	Clear	5
None	Paid	2E 2L 1 Batt	30	5	None	.2	1.2	None	5.0	6.4	None	34.3	34.3	28	Clear	11-25
None	Paid	1E 2L 1 Batt	16	3	None	.2	3.0	None	1.3	4.5	None	3.1	3.1	44	Clear	3
None	Paid	3E 2L 1S 1 Rescue	39	3	2.8	3.1	2.7	4.3	2.9	15.8	None	24.7	24.7	22	Clear	5-8
1-T	Paid	3E 2L 1 Batt 1 Div	34	2	None	.1	3.0	U	9.0	12.1	None	57.3	57.3	56	Cloudy	8-21
None	Paid	2E 2L 1S 1 Batt	35	2	None	None	4.8	4.4	9.3	18.5	None	14.7	14.7	67	Clear	8-12
None	Paid	3E 2L 1S 1 Batt 1 Div	44	2	None	.6	4.7	2.3	10.4	18	None	58.7	58.7	55	Clear	11
None	Paid	3E 2L 1S	45	6	6.8	6.5	6.2	5.0	6.8	31.3	6.1	53.8	59.9	47	Clear	8-12
3T	Paid	3E 2L 1 Batt 1 Div 1 Marine	45	1	None	1.0	1.0	2.0	18.8	22.8	None	26.8	26.8	76	Clear	11

New York

REMARKS FOR TABLE X

Fire No.

1. This fire had made substantial headway due to delay in reporting by unsupervised children who accidentally started and unsuccessfully attempted to extinguish it. Additional short delay due to unserviceable hydrant.

2. This fire believed started by children playing in bedroom. Fire spread retarded by nearly closed bedroom door. A good stop was made.

3. Power tools were used to make a good stop at this fire even though the alarm was delayed by the time, 2:13 A.M., the vacancy of the building, and the location of the origin within the building.

4. A good stop was made on 50-year-old building, (10 to 15 min) -- Started by a cigarette at early hour -- (5 A.M.) -- good team effort by fire companies, with no unusual problems.

5. Arson with the use of an accelerant and a slightly delayed alarm gave this fire time to totally involve two rooms upon arrival of first fire equipment.

6. Suspected arson in 65-year-old building and delayed discovery allowed the fire to involve total structure and extension to three story adjoining structure by the time the fire units arrived.

7. Spread of fire was very rapid in this 75-year-old building. Fire believed started by children playing with matches in basement, and discovery delayed because of "rear tenement" location in slum clearance location.

8. Arson by vandals using gasoline or similar petroleum product accounted for complete involvement of main hall and adjoining rooms in 5 min. Age of building with both horizontal and vertical arteries unprotected and the general state of disrepair aided fire spread.

9. This arson fire, with the use of an accelerant and 4 to 5 min delay of discovery, was difficult to fight due to type of building construction. It was nevertheless subdued with minimum damage to the structure and its contents.

10. Delayed discovery of fire in 60-year-old structure caused collapse of two-thirds of warehouse, hindering interior extinguishment, 5 min after arrival of lead units. The collapse also extended the overhaul operation.

TABLE XI

SUMMARY OF DATA FROM WHITE PLAINS FIRES

Fire Number	Occupancy Class and Description	Building Construction Class	Number of Stories (Height) (ft)	Total Building Area (ft^2)	Building Area Involved by Fire (Fire Area) A_2 (ft^2)	Extent of Structural Involvement	Number of Stories Involved by Fire	Elevation of Fire Origin (Stories)	Fire Time (min): Preburn T_p	Fire Time (min): Control T_c	Fire Time (min): Final Extinguishment and Overhaul T_e	Water Used for Control: Maximum Application Rate Q (gpm)	Water Used for Control: Total Quantity of Water Used (gals)	Water Used for Control: Application Density (gal/100 ft^2)	Water Used for Control: Maximum Application Rate Density (gpm/100 ft^2)	Ext. & Overhaul: Total Quantity of Water Used (gals)	Ext. & Overhaul: Application Density (gal/100 ft^2)	Fire Streams: Hand Hose (in.)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Residential	F-R	9 (78')	77175	150	1	1	7	5	9	64	63	200	133	42	50	33	1-1½
2	Residential	W	2B (30')	10725	150	1	1	1	67	10	10	95	175	117	63	25	17	1-1½ 1-1
3	Residential	M-J	6B (70')	147,000	200	1	1	6	180	14	141	164	225	112	82	95	48	2-1½
4	Residential	F-R	[illegible]B (48')	54250	200	1	1	4	43	6	90	82	60	30	41	20	10	1-1½
5	Residential	W	2B. (30')	3780	300	2	1	1	15	10	141	95	200	66	32	50	17	1-1 1-1½
6	Residential	W	2B (30')	32700	600	2	2	8	7	42	300	409	4500	750	68	1000	167	1-2½ 3-1½
7	Residential	W	2B (25')	3455	750	2	1	2	180	14	105	164	290	39	22	210	28	2-1½
8	Mercantile (Beauty Supply House)	F-R	1B (20')	1500	300	1	1	1	45	8	109	82	125	42	27	75	25	1-1½
9	Mercantile (Warehouse)	S-F	1	900	900	3	1	1	7	12	114	517	1050	117	57	350	39	2-1½ 3-2½
10	Educational & Industrial	S-F	6 (72')	45000	2200	2	1	3	14	18	110	145	335	15	7	145	7	2-1½

Fire Number	Fire Streams: Master	Fire Department: Type	Fire Department: Number of Working Companies	Fire Department: Total Manpower	Fire Department: Manpower per 100 ft^2 Fire Area	Use of Manpower: Rescue	Use of Manpower: Forcible Entry	Use of Manpower: Ventilation	Use of Manpower: Exposure Protection	Man-hours: Extinguishment	Man-hours: Total Man-hours - Columns 24 through 28	Man-hours: Salvage	Man-hours: Overhaul	Man-hours: Total Man-hours Columns 30 and 31	Temperature °F	Weather Data: Visibility	Weather Data: Wind Speed (mph)
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	None	Paid	3E 1L	14	9	.4	None	.5	None	.3	1.2	2.4	6.7	9.1	36	Clear	Calm
2	None None	Paid	3E 1L	16	10	.3	.1	.6	None	.6	1.6	7.2	1.9	9.1	44	Clear	5-10
3	None	Paid	3E 2L	20	10	.2	.1	.5	None	.6	1.4	21.5	11.2	32.7	55	Clear	12
4	None	Paid	3E 1L 1Batt	16	8	.4	.1	.3	None	.9	1.7	1.0	11.3	12.3	11	Clear	Calm
5	None	Paid	3E 1L 1Batt	16	5	.2	.1	.7	None	1.0	2.0	1.3	22.4	23.7	46	Rain	Calm
6	None	Paid	4E 2L	21	4	1.2	.8	1.3	None	7.7	11.0	56.1	23.8	79.9	28	Clear	Calm
7	None	Paid	4E 1L 1Batt	19	3	None	.3	.9	.1	12.9	14.2	.7	11.9	12.6	28	Clear	Calm
8	None	Paid	3E 1L	16	5	None	.1	.4	None	.5	1.0	1.0	22.2	23.2	41	Clear	Calm
9	None	Paid	4E 1L	17	2	None	None	None	.9	.9	1.8	.3	23.3	23.6	35	Clear	10-15
10	None	Paid	3E 2L	18	.8	1.7	None	3.3	None	.7	5.7	13.2	4.3	17.5	44	Clear	5-10

White Plains

REMARKS FOR TABLE XI

Fire No.

1. Child playing with matches started this fire which was reported and controlled quickly by fire fighters.

2. Possible spontaneous combustion of rags in kitchen started this fire in unoccupied apartment. It was quickly subdued by prompt, efficient fire department action.

3. Defective wiring believed responsible for this fire which smoldered for approximately 3 hrs before discovery.

4. Cigarette on couch probably caused this fire which smoldered and burned approximately 43 min. before discovery. Two house pets died because of this small fire which was confined to the living room.

5. Possible electrical fire -- alarm delayed because occupants were sleeping in rear bedroom, while fire started in front.

6. Thick black smoke complicated fire fighting operation of this basement oil fire started by a defective oil burner.

7. This fire, originating in second floor bathroom, is estimated to have burned 2 to 3 hrs before discovery. Building locked and unoccupied.

8. Delayed discovery because fire in rear of closed store went unnoticed until part of front window broke out.

9. This rapidly spreading fire was caused by accidental upsetting of kerosene salamander (heater) which ignited easily combustible materials in large undivided area.

10. Fire of unknown cause started in fourth floor storage area, burned for 10 min before being discovered.

TABLE XII

SUMMARY OF DATA FROM BUENA PARK FIRES

Fire Number	Occupancy Class and Description	Building Construction Class	Number of Stories (Height) (ft)	Total Building Area (ft²)	Building Area Involved by Fire (Fire Area) A_2 (ft²)	Extent of Structural Involvement	Number of Stories Involved by Fire	Elevation of Fire Origin (Stories)	Fire Time (min): Preburn T_p	Fire Time (min): Control T_c	Fire Time (min): Final Extinguishment and Overhaul T_e	Water Used for Control: Maximum Application Rate Q (gpm)	Water Used for Control: Total Quantity of Water Used (gals)	Water Used for Control: Application Density (gals/100 ft²)	Water Used for Control: Maximum Application Rate Density (gpm/100 ft²)	Ext. & Overhaul: Total Quantity of Water Used (gals)	Ext. & Overhaul: Application Density (gal/100 ft²)	Fire Streams: Hand Hose (in.)	Fire Streams: Master	Fire Department: Type	Fire Department: Number of Working Companies	Fire Department: Total Manpower	Fire Department: Manpower per 100 ft² Fire Area	Use of Manpower: Rescue	Use of Manpower: Forcible Entry	Use of Manpower: Ventilation	Use of Manpower: Exposure Protection	Man-hours: Extinguishment	Man-hours: Total Man-hours - Columns 24 through 28	Man-hours: Salvage	Man-hours: Overhaul	Man-hours: Total Man-hours Columns 30 and 31	Weather Data: Temperature °F	Weather Data: Visibility	Weather Data: Wind Speed (mph)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	Residential (Carport)	W	1	800	400	2	1	1	10	3	19	284	1800	450	71	2500	625	1-2½ 1-1½	None	Paid	2E 1AP 1S 1Batt	16	4	None	None	1.5	None	2.8	4.3	None	8.0	8.0	52	Clear	1
2	Residential (Garage)	W	1	441	441	2	1	1	5	10	190	300	1200	272	68	3400	771	4-1½	None	Paid	2E 1S 1Batt	10	2	1.0	None	2.1	.4	1.9	5.4	12.8	11.6	24.4	62	Clear	4
3	Residential & Garage	W	1	920	580	3	1	1	4	6	20	300	2450	422	52	3750	647	4-1½	None	Paid	2E 1S 1Batt	10	2	None	.2	1.5	None	3.0	4.7	7.6	4.2	11.8	80	Clear	3
4	Residential	W	1	1700	750	2	1	1	71	3	80	117	150	20	16	250	33	1-1½ 2-3/4	None	Paid	2E 1AP 1S 1Batt	17	2	1.1	.1	.9	None	1.1	3.2	8.6	25.7	34.3	54	Clear	1
5	Residential	W	1A	3200	940	2	1	1	27	4	59	225	500	53	24	2600	277	3-1½	None	Paid	2E 2S 1AP 1Batt	17	2	.8	None	2.5	None	3.5	6.8	2.6	6.1	8.7	72	Clear	1
6	Residential	W	1	1428	952	2	1	1	120	7	26	150	400	42	16	2000	210	2-1½	None	Paid	2E 1S 1Batt	9	.9	2.0	None	2.3	None	2.6	6.9	3.4	7.4	10.8	61	Clear	1
7	Residential	W	1	1248	1056	3	1	1	198	22	42	359	300	28	34	3100	294	2-1½ 1-2½	None	Paid	2E 1S 1Batt	11	1	.8	.1	None	.4	3.8	5.1	4.0	9.1	13.1	46	Clear	1
8	Industrial	M-J	1 (20')	2700	2100	3	1	1	30	22	113	1127	1000	1000	54	25000	1190	3-2½	1AP	Paid	3E 1S 1Batt 1AP	22	1	None	None	None	1.6	7.5	9.1	None	19.1	19.1	55	Clear	5
9	Public Assembly (Private Country Club)	W	1	20175	14375	4	1	1	36	59	725	1077	60000	417	7	290,000	201[illegible]	6-1½ 3-2½	None	Paid &Vol	3E 1S 1Batt 1Eng	16	.1	None	None	None	None	62.5	62.5	63.3	122.0	185.3	48	Clear	1
10	Mercantile	M-J	1	25000	20000	3	1	1	12	43	45	1100	40000	200	6	63600	31[illegible]	4-1½ 2-2½	None	Paid	3E 1S	14	.07	None	None	None	.4	8.4	8.4	4.1	4.9	9.0	52	Clear	3

Buena Park

REMARKS FOR TABLE XII

Fire No.

1. This small fire involved two cars and carport and had a good start because of delayed alarm and inability of civilians to use pump-tank extinguishers.

2. This fire gained headway rather rapidly due to the storage of flammable materials in the garage, even though there was no delay in reporting other than the normal time required to get to a phone and make the call.

3. Natural gas from small heater caused explosion when ignited by water heater. Many collected items in home, wall to wall with barely enough room to walk through, added fuel to the fire.

4. A cigarette dropped on a sofa probably started this fire which was delayed in being reported approximately 1 hr because the owners were not home.

5. Alarm was delayed about 20 min because owners were asleep. Fire started in garage and spread to kitchen through hollow core door.

6. An estimated 2 hr delay resulted in rapid spread of flames through super heated atmosphere in house. One of the sleeping occupants died from burns and smoke inhalation. Rescue efforts were hampered by intense heat and fog.

7. This fire burned for about 3 hrs before its discovery by neighbors, since owners were not at home. Dense fog caused fire to be unnoticed until it broke through roof.

8. Spontaneous combustion started fire in new building operating under temporary use permit. Alarm delayed 15 min and nonconnected sprinkler system allowed building to be fully involved in fire upon the arrival of the first engine company.

9. A delayed alarm gave fire time to make a large headway, and inadequate water supply slowed extinguishment.

10. Arson gave fire a fast start, and delayed alarm allowed building to become fully involved upon arrival of fire requipment.

APPENDIX B

WATER QUANTITIES, CONTROL TIMES AND MANPOWER USED IN SUPPRESSING FIRES

TABLE

WATER AND CONTROL TIME U

	Classes of Maximum Fire Area A_2 (ft^2)	Average Fire Area Within Each Class $\bar{A}_2$ (ft^2)					Frequency of Fire Areas $\bar{A}_2$					Average Appl: Density With: for Cont: (gpm/100 :		
		* Chgo	L.A.	N.Y.	W.P.	B.P.	Chgo	L.A.	N.Y.	W.P.	B.P.	Chgo	L.A.	N.Y.
Residential	0 - 500	304	220	202	200	421	28	1	2	5	2	55.4	40	93.5
	501 - 1000	730	-	631	675	806	14	-	2	2	4	41.5	-	75
	1001 - 1500	1290	1250	1400	-	1056	5	1	2	-	1	40	29	54.5
	1501 - 2000	1760	-	1965	-	-	6	-	2	-	-	24	-	27.5
	2001 - 2500	2180	-	-	-	-	[illegible]	-	-	-	-	31	-	-
	2501 - 3000	2820	-	-	-	-	1	-	-	-	-	29	-	-
	3001 - 3500	3200	-	-	-	-	2	-	-	-	-	15.5	-	-
	3501 - 4000	3560	-	-	-	-	2	-	-	-	-	46.5	-	-
	4001 - 4500	--	-	-	-	-	0	-	-	-	-	-	-	-
	4501 - 5000	4700	-	-	-	-	3	-	-	-	-	14.1	-	-
Non-residential	0 - 2000	665	877	800	600	-	22	4	1	2	-	60	239.5	65
	2001 - 4000	2830	-	3200	2200	2100	9	-	1	1	1	42	-	84
	4001 - 6000	4510	5280	-	-	-	5	1	-	-	-	26	39	-
	6001 - 8000	7500	8000	-	-	-	1	1	-	-	-	21	29	-
	8001 - 10000	9480	9520	-	-	-	7	1	-	-	-	39	3.4	-
	10001 - 12000	11250	11250	-	-	-	3	1	-	-	-	5	27	-
	12001 - 14000	12510	-	-	-	-	6	-	-	-	-	23	-	-
	14001 - 16000	15500	-	-	-	14375	2	-	-	-	1	19	-	-
	16001 - 18000	-	-	-	-	-	0	-	-	-	-	-	-	-
	18001 - 20000	19000	-	-	-	20000	4	-	-	-	1	19	-	-
	20001 - 22000	21200	-	-	-	-	1	-	-	-	-	18	-	-
	22001 - 24000	22370	-	-	-	-	2	-	-	-	-	12	-	-
	24001 - 26000	-	-	-	-	-	0	-	-	-	-	-	-	-
	26001 - 28000	-	-	-	-	-	0	-	-	-	-	-	-	-
	28001 - 30000	28400	-	-	-	-	1	-	-	-	-	8	-	-

* Chgo - Chicago   L.A. - Los Angeles   N.Y. - New York   W.P. - White Plains

ABLE XIII

E USED IN SUPPRESSING FIRES

pplication Rate ithin Each Class ontrol, P 00 ft^2)			Average Application Rate Within Each Class for Control, Q (gpm)					Average Quantity of Water Used for Control, W (gals)					Average Control Time Within Each Class T_c (min)				
Y.	W.P.	B.P.	Chgo	L.A.	N.Y.	W.P.	B.P.	Chgo	L.A.	N.Y.	W.P.	B.P.	Chgo	L.A.	N.Y.	W.P.	B.P.
.5	52	69.5	155	88.5	150	99.8	292	740	40	700	172	1500	14	3	14.5	9.8	6.5
[illegible]	45	27	302	-	475	286.5	198	1570	-	1800	2395	875	17	-	12	2.8	5
.5	-	34	508	368	780	-	359	3200	3200	6800	-	300	35	8	27	-	22
7.5	-	-	420	-	535	-	-	8000	-	6625	-	-	21	-	27	-	-
-	-	-	673	-	-	-	-	9400	-	-	-	-	29	-	-	-	-
-	-	-	810	-	-	-	-	5210	-	-	-	-	13	-	-	-	-
-	-	-	485	-	-	-	-	5125	-	-	-	-	32	-	-	-	-
-	-	-	1650	-	-	-	-	16300	-	-	-	-	58	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	668	-	-	-	-	14720	-	-	-	-	46	-	-	-	-
[illegible]	42	-	500	1383	520	300	-	4240	3588	3100	588	-	19	20.5	45	10	-
[illegible]	7	54	1240	-	2700	145	1127	30000	-	15000	335	21000	72	-	25	18	22
-	-	-	1160	2033	-	-	-	24000	82200	-	-	-	55	44	-	-	-
-	-	-	1580	2303	-	-	-	165000	58720	-	-	-	103	37	-	-	-
-	-	-	3600	319	-	-	-	231000	10000	-	-	-	100	31	-	-	-
-	-	-	540	3004	-	-	-	7500	55000	-	-	-	49	39	-	-	-
-	-	-	2820	-	-	-	-	240000	-	-	-	-	130	-	-	-	-
-	-	-	2950	-	-	-	1077	560000	-	-	-	60000	190	-	-	-	59
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	3600	-	-	-	1100	295000	-	-	-	40000	130	-	-	-	43
-	-	-	3760	-	-	-	-	340000	-	-	-	-	840	-	-	-	-
-	-	-	2570	-	-	-	-	512000	-	-	-	-	190	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	2380	-	-	-	-	272000	-	-	-	-	140	-	-	-	-

B.P. - Buena Park

TABL

MANPOWER USED IN

	CLASSES OF MAXIMUM FIRE AREA A_2 (ft^2)	CLASS MARK OF FIRE AREA	AVERAGE FIRE AREA, A_2 (Within Each Class) (ft^2)					AVERAGE MANPOWER (Per 100 ft^2 Fire Area)					RESCUE — Average Man-hours (Percent of Total) **			
			Chgo	L. A.	N. Y.	W. P.	B. P.	Chgo	L. A.	N. Y.	W. P.	B. P.	Chgo	L. A.	N. Y.	W. P.
Residential	0 - 500	250	304	220	202	200	421	12	2	25	8	3	1.3 (16)	1.8 (26)	2.3 (29)	.3 (19)
	501 - 1000	750	730	-	631	675	805	4	-	4	4	1.7	1.0 (11)	- -	0 (0)	1.2 (19)
	1001 - 1500	1250	1290	1250	1400	-	1056	4	7	3	-	1	0 (0)	0 (0)	2.8 (16)	- -
	1501 - 2000	1750	1760	-	1965	-	-	2	-	2	-	-	.8 (6)	- -	0 (0)	- -
	Average Use of Man-Hours Expended as a Percent of the Total												8	13	12	14
Nonresidential	0 - 2000	1000	665	704	800	600	-	7.6	8	.6	4	-	.4 (3)	0 (0)	6.8 (22)	0 (0)
	2001 - 4000	3000	2830	-	3200	2200	2100	1.7	-	1	.8	1	.8 (2)	- -	0 (0)	1.7 (30)
	4001 - 6000	5000	4510	5281	-	-	-	1.1	1	-	-	-	0 (0)	0 (0)	- -	- -
	6001 - 8000	7000	7500	8000	-	-	-	.4	.8	-	-	-	U* -	0 (0)	- -	- -
	8001 - 10000	9000	9480	9520	-	-	-	1.1	.4	-	-	-	2.3 (1)	.2 (1)	- -	- -
	10001 - 12000	11000	11250	11250	-	-	-	.2	.4	-	-	-	0 (0)	0 (0)	- -	- -
	12001 - 14000	13000	12510	-	-	-	-	.5	-	-	-	-	0 (0)	- -	- -	- -
	14001 - 16000	15000	15500	-	-	-	14375	.6	-	-	-	.1	1 -	- -	- -	- -
	16001 - 18000	17000	-	-	-	-	-	-	-	-	-	-	- -	- -	- -	- -
	18001 - 20000	19000	19000	-	-	-	20000	.9	-	-	-	.07	0 (0)	- -	- -	- -
	Average Use of Man-Hours Expended as a Percent of the total												1	.2	11	15

*U Denotes Unknown

** Numbers in parenthesis indicate percent of total

TABLE XIV

WER USED IN SUPPRESSING FIRES

USE OF MAN-HOURS EXPENDED																					
E		FORCIBLE ENTRY					VENTILATION					EXPOSURE PROTECTION					FINAL EXTINGUISHMENT				
-hours Total) **		Average Man-hours (Percent of Total)					Average Man-hours (Percent of Total)					Average Man-hours (Percent of Total)					Average Man-hours (Percent of Total)				
W. P.	B. P.	Chgo	L.A.	N. Y.	W. P.	B. P.	Chgo	L.A.	N. Y.	W. P.	B. P.	Chgo	L. A.	N. Y.	W. P.	B. P.	Chgo	L.A.	N.Y.	W. P.	B. P.
.3	1	1,8	.1	1.2	.1	0	1.0	1.5	1.3	.5	1.8	0.9	.5	1.5	0	.4	3.2	3	1.7	.7	2.4
(19)	(18)	(22)	(2)	(15)	(6)	(0)	(12)	(22)	(16)	(31)	(32)	(11)	(7)	(19)	0	(7)	(39)	(44)	(21)	(44)	(43)
1.2	1.3	1.6	-	.2	.6	.2	0.9	-	2.1	1.1	1.8	1.3	-	0	.1	0	4.2	-	3.1	10.3	2.6
(19)	(22)	(18)	-	(4)	(5)	(3)	(10)	-	(39)	(8)	(31)	(14)	-	0	(1)	(0)	(47)	-	(57)	(77)	(44)
-	.8	5.2	0	1.6	-	.1	2.5	.4	2.8	-	0	0.9	0	4.3	-	.4	9.7	1	6	-	3.8
-	(16)	(28)	(0)	(9)	-	(2)	(14)	(29)	(26)	-	0	(5)	(0)	(25)	-	(8)	(53)	(71)	(34)	-	(76)
-	-	2.5	-	.6	-	-	1.3	-	4.7	-	-	0	-	3.4	-	-	8.8	-	9.8	-	-
-	-	(18)	-	(3)	-	-	(10)	-	(25)	-	-	(0)	-	(18)	-	-	(66)	-	(54)	-	-
14	19	22	0.5	8	5.5	1.5	11.5	25.5	24	19.5	21	7.5	3.5	15	.5	5	51	59.5	41	60.5	53.5
0	-	2.7	1.2	6.5	.1	-	1.3	1.7	6.2	.4	-	19	2.3	5.0	.9	-	6.2	5.7	6.8	.6	-
(0)	-	(22)	(11)	(21)	(5)	-	(10)	(16)	(20)	(20)	-	(15)	(21)	(16)	(45)	-	(50)	(52)	(21)	(30)	-
1.7	0	8.3	-	1.0	0	0	3.5	-	1	3.3	0	4.9	-	2.0	0	1.6	24.8	-	18.8	.7	7.5
(30)	(0)	(20)	-	(4)	(0)	(0)	(8)	-	(4)	(58)	(0)	(12)	-	(8)	(0)	(18)	(58)	-	(84)	(12)	(82)
-	-	2.3	1.7	-	-	-	5.0	3.4	-	-	-	14.7	1.3	-	-	-	33	26.4	-	-	-
-	-	(4)	(5)	-	-	-	(9)	(10)	-	-	-	(27)	4	-	-	-	(60)	(81)	-	-	-
-	-	U	3.2	-	-	-	U	2.1	-	-	-	U	14.6	-	-	-	U	40.3	-	-	-
-	-	-	(5)	-	-	-	-	(3)	-	-	-	-	(24)	-	-	-	-	(68)	-	-	-
-	-	15.7	2.9	-	-	-	7.6	2.9	-	-	-	5.0	3.3	-	-	-	132	9.0	-	-	-
-	-	(10)	(16)	-	-	-	(5)	(16)	-	-	-	(3)	(18)	-	-	-	(81)	(49)	-	-	-
-	-	0.3	7.7	-	-	-	0	6.3	-	-	-	13.8	1.1	-	-	-	25	21.5	-	-	-
-	-	(1)	(21)	-	-	-	(0)	(17)	-	-	-	(35)	(3)	-	-	-	(64)	(59)	-	-	-
-	-	2.1	-	-	-	-	1.6	-	-	-	-	0	-	-	-	-	58	-	-	-	-
-	-	(3)	-	-	-	-	(3)	-	-	-	-	(0)	-	-	-	-	(94)	-	-	-	-
-	0	U	-	-	-	0	U	-	-	-	0	U	-	-	-	0	U	-	-	-	62.5
-	(0)	-	-	-	-	(0)	-	-	-	-	(0)	-	-	-	-	(0)	-	-	-	-	(100)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	0	3.8	-	-	-	0	11.4	-	-	-	0	7.0	-	-	-	.4	249	-	-	-	8.4
-	(0)	(1)	-	-	-	(0)	(4)	-	-	-	(0)	(3)	-	-	-	(5)	(92)	-	-	-	(95)
15	0	6	12	12.5	2.5	0	4	12	12	39	0	15	14	12	22.5	7	74	61.8	52.5	21	93

TABLE XI

MANPOWER USED IN SUP

	Classes of Maximum Fire Area, A_2 (ft^2)	TOTAL MAN-HOURS EXPENDED (Up to & Including Extinguishment)					SALVAGE Average Man-hour (Percent of Tota			
		Chgo	L.A.	N. Y.	W. P.	B. P.	Chgo	L.A.	N. Y.	W
Residential	0 - 500	8.2	6.9	8.0	1.6	4.5	0.9	2,8	0	6
							(9)	(9)	(0)	(
	501 - 1000	9.0	-	5.4	13.3	5.9	1.0	-	0	28
							(6)	-	(0)	(
	1001 - 1500	18.3	1.4	17.5	-	5.1	1.9	.6	0	
							(9)	(13)	(0)	
	1501 - 2000	13.4	-	18.5	-	-	1.9	-	0	
							(12)	-	(0)	
	Average Use of Man-hours Expended as a Percent of Total						9	11	0	5
Nonresidential	0 - 2000	12.5	10.9	31.3	2.0	-	1.3	3.4	6.1	.
							(11)	(8)	(10)	
	2001 - 4000	42.3	-	22.8	5.7	9.1	15	-	0	1
							(26)	-	(0)	
	4001 - 6000	55.0	32.8	-	-	-	0	2.9	-	
							(0)	(3)	-	
	6001 - 8000	U	60.2	-	-	-	U	.8	-	
							-	(.5)	-	
	8001 - 10000	162.6	18.1	-	-	-	7	1.9	-	
							(7)	(3)	-	
	10001 - 12000	39.1	36.6	-	-	-	5	11.7	-	
							(8)	(12)	-	
	12001 - 14000	61.7	-	-	-	-	0	-	-	
							(0)	-	-	
	14001 - 16000	U	-	-	-	62.5	U	-	-	
							-	-	-	
	16001 - 18000	-	-	-	-	-	-	-	-	
							-	-	-	
	18001 - 20000	271.2	-	-	-	6.8	2.2	-	-	
							(1)	-	-	
	Average Use of Man-hours Expended as a Percent of Total						8	5	5	

BLE XIV

IN SUPPRESSING FIRES (Continued)

GE n-hours f Total)			OVERHAUL Average Man-hours (Percent of Total)					TOTAL MAN-HOURS EXPENDED (For Salvage & Overhaul)				
Y.	W. P.	B. P.	Chgo	L.A.	N. Y.	W. P.	B. P.	Chgo	L. A.	N. Y.	W. P.	B. P.
	6.7	12.8	9.6	29.6	7.4	10.7	9.8	10.5	32.4	7.4	17.4	22.6
	(39)	(57)	(91)	(91)	(100)	(61)	(43)					
	28.4	5.6	15.8	-	18.7	17.8	10.9	16.8	-	18.7	46.2	16.5
	(61)	(34)	(94)	-	(100)	(39)	(66)					
	-	4	19.1	4	41	-	9.1	21.0	4.6	41	-	13.1
	-	(31)	(91)	(87)	(100)	-	(69)					
	-	-	14.1	-	36.7	-	-	16.0	--	36.7	-	-
	-	-	(88)	-	(100)	-	-					
	50	41	91	89	100	50	59					
	.6	-	11.0	38.4	53.8	22.7	-	12.3	41.8	59.9	23.3	-
)	(3)	-	(89)	(92)	(90)	(97)	-					
	13.2	0	41.8	-	26.8	4.3	19.1	56.8	-	26.8	17.5	19.1
	(75)	(0)	(74)	-	(100)	(25)	(100)					
	-	-	31.1	97.8	-	-	-	31.1	100.7	-	-	-
	-	-	(100)	(9.7)	-	-	-					
	-	-	U	148.7	-	-	-	U	149.5	-	-	-
	-	-	-	(99.5)	-	-	-					
	-	-	98	57.4	-	-	-	105	59.3	-	-	-
	-	-	(93)	(97)	-	-	-					
	-	-	6.0	84.8	-	-	-	6.5	96.5	-	-	-
	-	-	(92)	(88)	-	-	-					
	-	-	84	-	-	-	-	84	-	-	-	-
	-	-	(100)	-	-	-	-					
	-	63.3	U	-	-	-	122.0	U	-	-	-	-
	-	(34)	-	-	-	-	(66)					
	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-					
	-	4.1	178	-	-	-	4.9	180	-	-	-	90
	-	(46)	(99)	-	-	-	(54)					
	39	27	92	95	95	61	73					

SYMBOLS AND ABBREVIATIONS USED IN TABLES IX, X, XI, AND XII

Building Construction - Columns 2 and 3

W Wood construction

F-R Fire resistive

M-J Masonry-joist (Brick or Concrete block walls, wood floors and roof)

M-C Metal clad

S-F Steel frame

Number of Stories - Column 3

A Attic (Also Involved)

B Basement (Also Involved)

Fire Streams - Columns 18 and 19

Column 18 shows Number and Size of Hoses used.

Column 19 - AP = Aerial Platform

Master Stream, T = Turret Nozzle Master Stream

LP Ladder Pipe Master Stream

Type of Fire Department - Column 20 - Paid or Volunteer

Fire Apparatus - Column 21

E Engine Company

L Ladder Company

Batt Battalion Chief

S Squad Company

Div Division Chief

SL Skip Loader (Rubber Tired B)

HU Heavy Utility Company (Wrecker)

AU Air Utility (Panel Truck with air compressor and tanks)

LW Light Wagon (Portable Electric Lights)

SU Service (Provides food and coffee)

Eng Chief Engineer

Rescue Rescue Squad Company

Marine Fire Boat

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13. ABSTRACT

Fire department operations were studied in New York, N.Y., White Plains, N.Y., Los Angeles, California and Buena Park, California. The study was performed using data on ten fires in each city. Correlations were developed involving water application, time and manpower required for suppressing various sizes of structural fires. Results were compared with fire department operations within the Chicago Metropolitan Area that were determined in other studies.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Fire fighting, equipment						
Fire fighting, water usage						
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Fire control						
Fire extinguishment						